PB89-221444

Best Demonstrated Available Technology (BDAT) Background Document for Organophosphorous Wastes

Versar, Inc., Springfield, VA

Prepared for:

Environmental Protection Agency, Washington, DC

Jun 89

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/530-SW-89-048G	2.	3. PB89-221444
4. Title and Subtitle Best Demonstrated Available Technology (BDAT) Background Document for Organophosphorous Wastes			5. Report Date June 1989 6.
7. Author(s) Robert April/Mary Cunningham/Office of Solid Waste			8. Performing Organization Rept. No
9. Performing Organization Name and Address U.S. EPA Office of Solid Waste 401 M. Street SW Washington, DC 20460			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) 68-01-7053 (G)
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This background document provides the Agency's technical support for selecting and developing treatment standards for the constituents to be regulated in these organophosphorous wastes. Section 2 presents waste-specific informatiopn; Section 3 discusses the applicable and demonstrated technologies used to treat these wastes; Section 4 presents the available performance data; Section 5 explains EPA's determination of BDAT; while Section 6 discusses the selection of constituents to be regulated and Section 7 presents treatment standards for these constituents.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
RELEASE UNLIMITED	UNCLASSIFIED	0
	20. Security Class (This Page) UNCLASSIFIED	22. Price 0

(ANSI-Z39.18) OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

(3)

EPA/530-SW-89-048G

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT FOR

ORGANOPHOSPHOROUS WASTES

Robert April, Chief
Treatment Technology Section

Mary Cunningham
Project Manager

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street, S.W.
Washington, D.C. 20460

June 1989

ACKNOWLEDGMENTS

This document was prepared by the U.S. Environmental Protection Agency, Office of Solid Waste, with the assistance of Versar Inc. under Contract No. 68-01-7053. Mr. Robert April, Acting Chief, Treatment Technology Section, Waste Treatment Branch, served as the EPA Program Manager during the preparation of this document and the development of treatment standards for the organophosphorous wastes. The technical project officer for the waste was Ms. Mary Cunningham. Mr. Steven Silverman served as legal advisor.

Versar personnel involved in the preparation of this document included Mr. Jerome Strauss, Program Manager; Mr. Stephen Schwartz, Task Manager; Ms. Josephina Castellanos, Staff Engineer; Ms. Barbara Malczak, Technical Editor; and Ms. Sally Gravely, Project Secretary.

The Agency wishes to thank Monsanto for submitting data on the treatment of Parathion.

TABLE OF CONTENTS

Section		Page
1.	INTRODUCTION	1-1
2.	INDUSTRY AFFECTED AND WASTE CHARACTERIZATION	2-1
	2.1 Industry Affected and Process Description	2-1
	2.2 Waste Characterization	2-3
	2.3 Determination of Waste Treatability Group	2-8
3.	APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES	3-1
	3.1 Applicable Treatment Technologies	3-1
	3.2 Demonstrated Treatment Technologies	3-3
4.	PERFORMANCE DATA BASE	4-1
5.	IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY	5-1
	5.1 Nonwastewaters	5-2
	5.2 Wastewaters	5-3
6.	SELECTION OF REGULATED CONSTITUENTS	6-1
	6.1 Identification of BDAT List Constituents	6-1
	6.2 Constituent Selection	6-2
7.	DEVELOPMENT OF BDAT TREATMENT STANDARDS	7-1
8.	REFERENCES	8-1

LIST OF TABLES

Table		Page
1-1	Treatment Standards for the Organophosphorous Wastes	1-4
2-1	Number of Facilities and Volume of Organophosphorous P and U Wastes Generated in 1986	2-6
2-2	Available Characterization Data for K038	2-7
2-3	Available Characterization Data for K039	2-8
2-4	Available Characterization Data for K040	2-9
4-1	Biological Treatment for Parathion	4-5
6-1	Waste Characteristics Affecting Performance of Incineration	6-4
6-2	Regulated Constituents for K038, K039, and K040	6-4
7-1	BDAT Nonwastewater Treatment Standards for K038 and K040.	7-3
7-2	BDAT Wastewater Treatment Standards for K038 and K040 ...	7-4

LIST OF FIGURES

Figures		Page
2-1	Phorate Production	2-5
2-2	Chemical Structures for P and U Wastes	2-12
4-1	Phorate Chemical Structure	4-3
4-2	Disulfoton Chemical Structure	4-3

1. INTRODUCTION

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act (RCRA) as enacted by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, the Environmental Protection Agency (EPA) is establishing treatment standards based on the best demonstrated available technology (BDAT) for the waste treatability group identified as organophosphorous wastes. These wastes are identified in 40 CFR 261.32 as K038, K039, and K040; in 40 CFR 261.33, they are identified as P039, P040, P041, P043, P044, P062, P071, P085, P089, P094, P097, P109, P111, U058, U087, and U235. The Agency is also establishing standards for the wastewater forms of K036. A treatment standard of "No Land Disposal Based on No Generation" was promulgated for the nonwastewater forms of K036 on August 8, 1988. EPA amended this standard to apply only to wastes generated from a process meeting the listing description and disposed of after August 17, 1988 (54 FR 18836 - May 2, 1989). Compliance with these BDAT treatment standards is a prerequisite for the placement of these wastes in land disposal units. The effective date of these treatment standards is June 8, 1989.

This background document provides the Agency's technical support for selecting and developing treatment standards for the constituents to be regulated in these organophosphorous wastes.

The principal constituents of concern in each of these wastes are members of a group of organic compounds known as organophosphorous compounds. The majority of these constituents also contain sulfur and are often referred to as phosphorothioates. All of these compounds are somewhat similar in structure and elemental content. Most are typically manufactured for use as pesticides. Therefore, the Agency has classified all of these compounds as one treatability group identified as the organophosphorous pesticides.

Section 2 presents waste-specific information--the number and location of facilities affected by the land disposal restrictions, the waste-generating process, and the waste characterization data. Section 3 discusses the applicable and demonstrated technologies used to treat these wastes (or similar wastes). Section 4 presents the available performance data, including data on which the treatment standards are based. Section 5 explains EPA's determination of BDAT, while Section 6 discusses the selection of constituents to be regulated and Section 7 presents treatment standards for these constituents.

The BDAT program and promulgated methodology are more thoroughly described in two additional documents: Methodology for Developing BDAT Treatment Standards (USEPA 1988c) and Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (USEPA 1987). The petition process that must be followed when requesting a variance from the BDAT treatment standards is discussed in the methodology document.

For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.

The Agency is promulgating numerical performance standards for Disulfoton in K036 wastewaters and in P039 wastewaters and nonwastewaters; Phorate in K038, K040, and P094 wastewaters and nonwastewaters; and Methyl Parathion, Parathion, Famphur, and tris-(2,3-dibromopropyl) phosphate in P071, P089, P097, and U235 wastewaters and nonwastewaters, respectively. If the concentrations of the regulated constituents, as generated, are lower than or equal to the BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal. The treatment standards for the wastewater forms of these wastes are based on transfer of biological treatment data received during the comment period for the Second Third wastes proposed treatment standards; and the treatment standards for the nonwastewater forms are based on a transfer from the incineration performance data for K037.

---

* The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by Method 209c (Total Suspended Solids Dried at 103 to 105°C) in Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, and WPCF 1985).

In addition, the Agency is setting technology-based BDAT standards for the wastewater and nonwastewater forms of K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087, requiring that specific treatment technologies be used to treat the wastes. The treatment standard for the wastewater forms of these wastes requires that incineration or carbon adsorption followed by incineration be used. The treatment standard for the nonwastewater forms of these wastes requires incineration as a treatment technology.

Table 1-1 presents the treatment standards for the organophosphorous wastes.

Table 1-1 Treatment Standards for the Organophosphorous Wastes

Waste code	Regulated constituent	Wastewaters (ppm)	Nonwastewaters (ppm)
K036	Disulfoton	0.025	-
K038	Phorate	0.025	0.10
K039	-[a]	Carbon adsorption or incineration	Incineration
K040	Phorate	0.025	0.10
P039	Disulfoton	0.025	0.10
P040	-[a]	Carbon adsorption or incineration	Incineration
P041	-[a]	Carbon adsorption or incineration	Incineration
P043	-[a]	Carbon adsorption or incineration	Incineration
P044	-[a]	Carbon adsorption or incineration	Incineration
P062	-[a]	Carbon adsorption or incineration	Incineration
P071	Methyl parathion	0.025	0.10
P085	-[a]	Carbon adsorption or incineration	Incineration
P089	Parathion	0.025	0.10
P094	Phorate	0.025	0.10
P097	Famphur	0.025	0.10
P109	-[a]	Carbon adsorption or incineration	Incineration
P111	-[a]	Carbon adsorption or incineration	Incineration
U058	-[a]	Carbon adsorption or incineration	Incineration
U087	-[a]	Carbon adsorption or incineration	Incineration
U235	Tris-(2,3-Dibromopropyl) phosphate	0.025	0.10

[a]For this waste code, EPA is not regulating a specific constituent level but instead is requiring a technology that must be used to treat the wastes.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

This section describes the industry affected by the land disposal restrictions for K038, K039, and K040 and presents available characterization data for these wastes. Because the Agency believes that K036 is no longer generated by manufacturing processes, the Agency does not have characterization data for this waste. Characterization data also are not available for any of the P and U wastes.

Under 40 CFR 261.32, wastes identified as K038, K039, and K040 are specifically generated in the production of Phorates and K036 is generated in the production of Disulfoton. These wastes are listed as follows:

K036: Still bottoms from toluene reclamation distillation in the production of Disulfoton.

K038: Wastewater from the washing and stripping of Phorate production.

K039: Filter cake from the filtration of diethylphosphorodithioic acid in the production of Phorate.

K040: Wastewater treatment sludge from the production of Phorate.

According to 40 CFR 261.33, the following materials are hazardous wastes when they are discarded or are intended to be discarded; when they are mixed with waste oil, used oil, or another material; when they are applied to the land or are contained in products that are applied to the land, and when they are burned as fuel:

P039 Disulfoton
P040 O,O-diethyl O-pyrazinyl phosphorothioate
P041 Diethyl-P-nitrophenyl phosphate
P043 Diisopropyl fluorophosphate (DEP)
P044 Dimethoate

P062 Hexaethyl tetraphosphate
P071 Methyl parathion
P085 Octamethylpyrophosphoramide
P089 Parathion
P094 Phorate
P097 Famphur
P109 Tetraethyl dithiopyrophosphate
P111 Tetraethyl pyrophosphate
U059 Cyclophosphamide
U087 O-O-diethyl-5-methly-dithiophosphate
U235 1-propanol, 2,3-dibromo-,phosphate (3:1)

These materials can be present in different forms:

- Any commercial or off-specification commercial chemical product with any of the above generic names;
- Residues remaining in containers that held any of the above-mentioned products; or
- The residue of contaminated soil, water, or other debris that results when there is a cleanup of a commercial or off-specification commercial chemical product or manufacturing chemical intermediate having the generic name of any of the above-listed products that had been spilled onto the land or into the water.

The Agency has examined the source of the wastes, specific similarities in waste composition, elemental content of the constituents of concern in each waste, applicable and demonstrated treatment technologies, and attainable treatment performance in order to support the approach proposed for these listed wastes.

2.1 Industry Affected and Process Description

The four-digit Standard Industrial Classification (SIC) code associated with the production of Phorates is 2818 (Organic Pesticide Products). The Agency believes that only one facility currently produces Phorates and generates K038 and K039 wastes. This facility is located in EPA Region VII in the State of Missouri. Based on the National Survey of

Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities of 1986 (the TSDR Survey), the Agency believes that K040 is no longer generated. Nevertheless, as a precaution, EPA has decided to set BDAT treatment standards for this waste as well.

The production of Phorates typically consists of the reaction of O,O-diethyl hydrogen phosphorodithioate with formaldehyde, followed by the addition of ethyl mercaptan (ethanethiol). The O,O-diethyl hydrogen phosphorodithioate is condensed with formaldehyde and ethyl mercaptan.

The reaction chemistry is as follows:

$$\underset{\substack{\text{phosphorous}\\\text{pentasulfide}}}{P_2S_5} + \underset{\text{ethanol}}{4C_2H_5OH} \longrightarrow \underset{\substack{\text{O,O-diethyl}\\\text{hydrogen}\\\text{phosphorodithioate}}}{2(C_2H_5O)_2PSH} + H_2S$$

$$\underset{\substack{\text{O,O-diethyl}\\\text{hydrogen}\\\text{phosphorodithioate}}}{(C_2H_5O)_2PSH} + \underset{\text{formaldehyde}}{H_2C{=}O} \longrightarrow \underset{\text{dithiophosphate}}{(C_2H_5O)_2PS\text{-}CH_2OH}$$

$$\underset{\text{dithiophosphate}}{(C_2H_5O)_2PS\text{-}CH_2OH} + \underset{\substack{\text{ethyl}\\\text{mercaptan}}}{C_2H_5SH} \longrightarrow \underset{\text{Phorate}}{(C_2H_5O)_2P\text{-}SCH_2SC_2H_5} + H_2O$$

Three hazardous waste streams are expected to be generated from the production of Phorate:

1. Process wastewater (K038), which is likely to contain significant concentrations of Phorate and lesser concentrations of other process waste constituents including formaldehyde, phosphorodithioic and phosphorothioic acid esters, and other main reaction byproducts;

2. A filter cake (K039), which is expected to contain high concentrations of esters of phosphorodithioic acid and esters of phosphorothioic acid; and

3. Wastewater sludges (K040) resulting from the treatment of process waters. These sludges are expected to contain high concentrations of Phorate because of its relative insolubility in water. Lesser concentrations of other process constituents are also expected to be found in the sludge.

Figure 2-1 illustrates the sources of these waste streams of concern.

P039, P040, P041, P043, P044, P062, P071, P085, P089, P094, P097, P109, P111, U058, U087, and U235 are generated from spills, leaks, or the discarding of chemicals associated with the production and marketing of the constituents in each waste.

Table 2-1 presents the number of RCRA permitted facilities that generated the above-listed wastes and the approximate volumes produced in 1986 (CBI information is not included). The Agency estimates that about 142,797 gallons of these wastes were generated in 1986.

2.2 Waste Characterization

This section provides all waste characterization data obtained by the Agency for K038, K039, and K040. Tables 2-2, 2-3, and 2-4 present, by waste code, the BDAT list constituents and other parameters identified for each waste. The K038 wastes are expected to contain Phorate, phosphorodithioic acid esters, phosphorothioic acid esters, and formaldehyde. As seen on Table 2-2, the concentration of Phorate, an organophosphorous insecticide, is 50 ppm. No BDAT list constituents, except Phorate, were detected at treatable concentrations in the untreated K038 waste sample. The K039 wastes contain phosphorodithioic

CBI

FIGURE 2-1 PHORATE PRODUCTION

Table 2-1 Number of Facilities and Volume of Organophosphorous P and U Wastes Generated in 1986

Waste code	No. of facilities	Volume produced (gallons)
P039	2	13,920
P040	2	270
P041	1	1
P043	2	2
P044	7	19,252
P062	0	0
P071	5	40,328
P085	1	1
P089	7	52,801
P094	2	14,880
P097	0	0
P109	0	0
P111	0	0
U058	2	380
U087	1	961
U235	1	1

Reference: USEPA 1986b.

Table 2-2 Available Characterization Data for K038

	Untreated waste concentration
BDAT list organics	
Organophosphorous insecticides	
Phorate	50.0 ppm
Other organics	
Phosphorothioic acid esters	0.5 ppm
Phosphorodithioic acid esters	5.0 ppm
Formaldehyde	5.0 ppm
Other constituents	
Water[a]	>99 %

[a]K038 is an aqueous waste whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however

Reference: Environ Corporation. n.d.

Table 2-3 Available Characterization Data for K039

	Untreated waste concentration
Non-BDAT list organics	
Phosphorodithioic acid triethyl esters	10%
Phosphorothioic acid triethyl esters	1%
Other constituents	
Water[a]	89%

[a]K039 is a non-aqueous waste, whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however

Reference: Environ Corporation. n.d.

Table 2 4 Available Characterization Data for K040

	Untreated waste concentration
BDAT list organics	
Organophosphorous insecticides	
Phorate	2,500 ppm
Other organics	
Phosphorodithioic acid triethyl esters	21,000 ppm
Phosphorothioic acid triethyl esters	2,000 ppm
Formaldehyde	300 ppm
Other constituents	
Water[a]	>97%

[a]K040 is a non-aqueous waste, whose only other constituent is expected to be water. This characteristic was not specifically stated on the data source, however.

Note: It appears that this waste is no longer produced.

Reference: Environ Corporation. n.d.

acid esters and phosphorothioic acid esters. While these are Appendix VII constituents, they are not part of the BDAT list because they currently cannot be analyzed at the treated concentrations. Therefore, EPA could not enforce any proposed quantitative regulation for these constituents. The K040 waste contains Phorate, formaldehyde, phosphorodithioic acid triethyl ester, and phosphorothioic acid triethyl ester. As seen on Table 2-4, the concentration of Phorate in the waste is 2,500 ppm. No other BDAT list constituent is expected to be present in the untreated waste.

Characterization data identified in the literature for K038, K039, and K040 do not provide values for concentrations of BDAT list metals. There is no reason to suspect that BDAT list metals are present in these wastes.

2.3 Determination of Waste Treatability Group

If EPA believes that the same technologies can be used to treat constituents present in wastes represented in different codes to similar concentrations, the Agency may combine the codes into one separate treatability group.

Based on review of the generation of the wastes, waste compositions, waste management practices, and all available data characterizing these wastes, the Agency has determined that K036, K038, K039, K040, P039, P040, P041, P043, P044, P062, P071, P085, P089, P094, P097, P109, P111, U058, U087, and U235 wastes represent a single waste treatability group. The Agency has grouped these wastes together because of similarities in structure and elemental content of the primary constituent of concern in

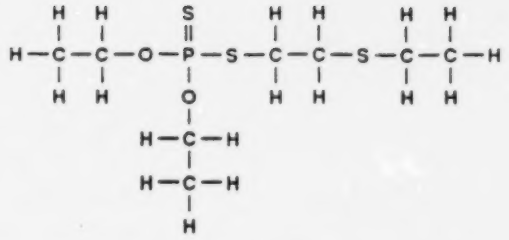
each waste (see Figure 2-2). All of the chemicals represented by these waste codes are organophosphorous compounds.

Although the concentrations of specific constituents will vary from one waste code to another, all of these wastes contain similar constituents and are expected to be treatable to similar levels using the same technologies. Consequently, EPA has examined the sources and characteristics of these wastes, their applicable and demonstrated treatment technologies, and their attainable treatment performance in order to determine a single regulatory approach that would be applicable for these wastes.

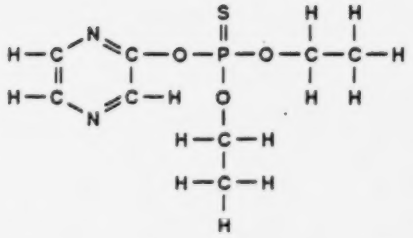
Even though constituents in all the wastes are similar to each other and to Disulfoton (the regulated constituent in K037), the Agency is setting concentration-based standards for some of these organophosphorous wastes (i.e., those that have analytical methods) and technology-based standards for the others.

The Agency is setting concentration-based standards for the wastewater and nonwastewater forms of K038, K040, P039, P071, P089, P094, P097, and U235; and for the wastewater forms of K036 since there are EPA-approved analytical methods for the constituents of these wastes. The analytical methods according to SW-846 (USEPA 1986a) are the following:

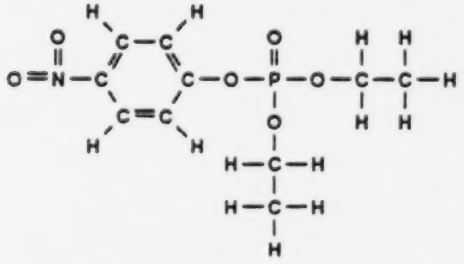
Waste Code	Constituent	Analytical Method
K038, K040, P094	Phorate	8270, 8140
K036, P039	Disulfoton	8140
P071	Methyl parathion	8140
P089	Parathion	8270
P097	Famphur	8270
U235	1-propanol, 2,3-dibromo-, phosphate (3:1)	8350



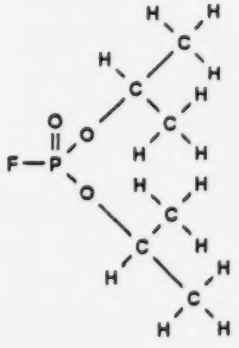
P039: DISULFOTON



P040: O,O-DIETHYL O-PYRAZINYL PHOSPHOROTHIOATE

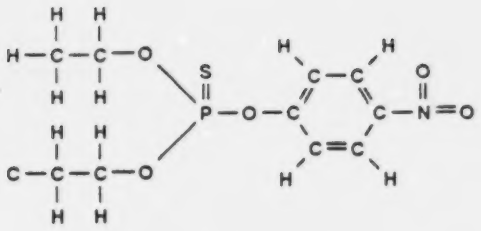


P041: DIETHYL P-NITROPHENYL PHOSPHATE

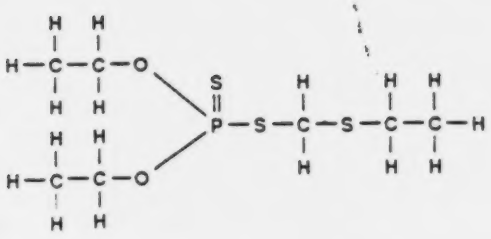


P043: DIISOPROPYL FLUOROPHOSPHATE

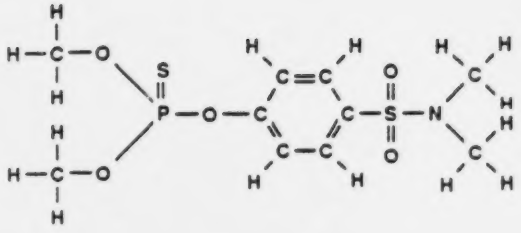
Figure 2-2 Chemical Structures for P and U Wastes



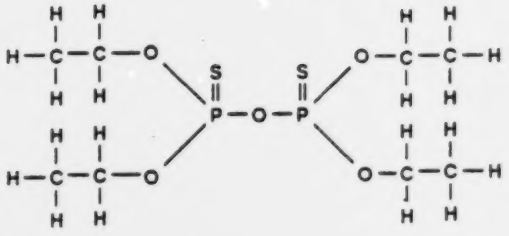
P089: PARATHION



P094: PHORATE

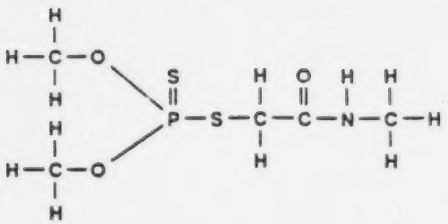


P097: FAMPHUR

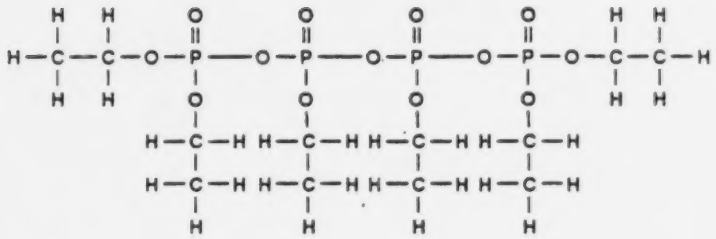


P109: TETRAETHYLDITHIOPYROPHOSPHATE

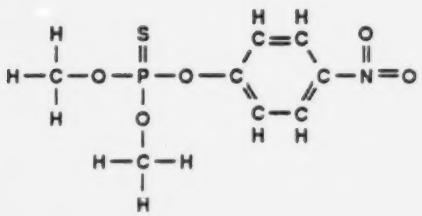
Figure 2-2 (Continued)



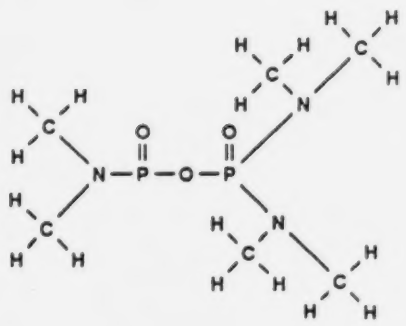
P044: DIMETHOATE



P062: HEXAETHYL TETRAPHOSPHATE

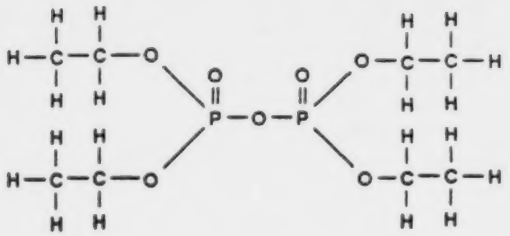


P071: METHL PARATHION

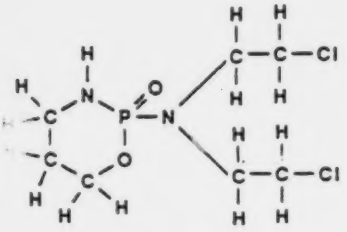


P085: OCTAMETHYLPYROPHOSPHORAMIDE

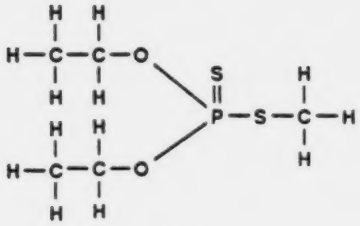
Figure 2-2 (Continued)



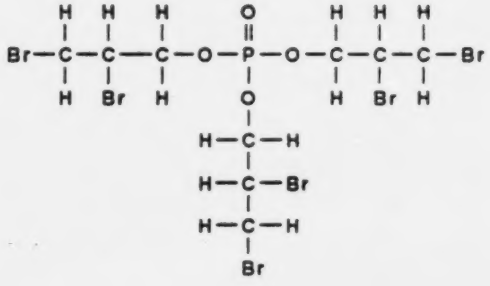
P111: TETRAETHYL PYROPHOSPHATE



U058: CYCLOPHOSPHAMIDE



U087: O-O-DIETHYL-S-METHYL-DITHIOPHOSPHATE



U235: 1-PROPANOL, 2,3-DIBROMO-, PHOSPHATE (3:1)

Figure 2-2 (Continued)

Method 8270 of SW-846 has been proposed in the January 23, 1989, update to the Third Edition of SW-846. Method 8350 will be included in the second update to the Third Edition of SW-846, due to be proposed in early 1990.

The Agency determined that the analytical methods available during the development of the phosphorous wastes BDAT standards could not satisfactorily measure the principal hazardous organic constituents (organophosphorous pesticide) contained in wastes and treatment residuals for wastes identified as K039, P040, P041, P043, P044, P062, P085, P109, P111, U058 and U087. Thus, the Agency is unable to promulgate concentration-based treatment standards for these wastes and is promulgating methods of treatment.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

This section identifies the treatment technologies that are applicable to this group and determines which, if any, of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology theoretically must be usable to treat the waste in question or to treat a waste that is similar in terms of the parameters that affect treatment selection. (For detailed descriptions of the technologies applicable for these wastes or for wastes judged to be similar, see EPA's Treatment Technologies Background Document (USEPA 1988d).) To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or a similar waste. Technologies that are available only at research facilities or at pilot- and bench-scale operations are not typically considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

Since the organophosphorous wastes contain organics, the technologies applicable to the untreated listed wastes should include those that destroy or reduce the total amount of various organic compounds in the waste.

For nonwastewaters, the Agency has identified incineration as an applicable treatment technology to treat the organophosphorous wastes. Technologies such as fuel substitution and solvent extraction also may be applicable to the treatment of the above-mentioned wastes as generated.

In addition, the Agency believes that wet air oxidation, incineration, biological treatment, and carbon adsorption are applicable to treat the wastewater forms of the organophosphorous wastes.

Incineration is a destruction technology in which energy, in the form of heat, is transferred to the waste to destabilize chemical bonds and eventually destroy hazardous constituents by converting them to carbon dioxide, water, and other oxidized waste constituents. In general, the two residuals generated by incineration processes are ash and combustion gas scrubber water.

Biological treatment is a technology that uses living microorganisms to decompose organic constituents. Biological treatment can occur either in the presence of oxygen, where it is known as aerobic treatment, or in the absence of oxygen, where it is referred to as anaerobic treatment. The organic constituents are broken down into water, carbon dioxide, and other organic constituents by the microorganisms.

Carbon adsorption is a separation technology used to remove and/or recover dissolved organics and certain inorganics from aqueous streams by adsorbing the dissolved constituents on the surface of the activated carbon particles. Powdered or granular activated carbon particles are used as the adsorbing medium in this technology.

3.2 Demonstrated Treatment Technologies

Of the above-mentioned technologies applicable for BDAT list organic constituents, the Agency believes that incineration is demonstrated to treat the nonwastewater and the wastewater forms of the organophosphorous

wastes, since this technology is currently being used by one facility to treat some of these wastes. Incineration is also being used to treat similar wastes (e.g., K037, wastewater treatment sludge from the production of Disulfoton).

The Agency considers carbon adsorption to be a demonstrated technology for the wastewater forms of these wastes, since carbon adsorption is being used to treat constituents with characteristics similar to the organophosphorous wastes. EPA believes that the organic constituents in these wastes can easily be adsorbed on carbon because of the chemical and physical properties of the compounds (such as their molecular weight, elemental composition, and structural forms).

The Agency has identified one facility that uses biological treatment on wastewaters containing Parathion. Therefore, EPA considers biological treatment to be a demonstrated technology for the wastewater forms of the organophosphorous wastes. Biological treatment data were provided during the comment period for the Land Disposal Restrictions for Second Third Scheduled wastes; Proposed Rule (54 FR 1056, January 19, 1989). This technology has been used to treat Parathion which the Agency believes is similar to these wastes and indeed is included in this treatability group.

4. PERFORMANCE DATA BASE

This section presents the data available on the performance of demonstrated technologies in treating the listed wastes. These data are used elsewhere in this document for determining which technologies represent BDAT (Section 5), for selecting constituents to be regulated (Section 6), and for developing treatment standards (Section 7). Eligible data may include data developed at bench- or pilot-scale facilities or obtained through other applications at less than full-scale operation, as long as the technology is demonstrated in full-scale operation for a similar waste or wastes.

Performance data, to the extent that they are available to EPA, include the untreated and treated waste concentrations for a given constituent, the values of operating parameters that were measured at the time the waste was being treated, the values of relevant design parameters for the treatment technology, and data on waste characteristics that affect performance of the treatment technology.

Where data are not available on the treatment of the specific wastes of concern, the Agency may elect to transfer data on the treatment of a similar waste or wastes, using a demonstrated technology. To transfer data from another waste category, EPA must find that the wastes covered by this background document are no more difficult to treat (based on the waste characteristics that affect performance of the demonstrated treatment technology) than the treated wastes from which performance data are being transferred.

The Agency has no data to characterize treatment for the nonwastewater forms of the listed wastes; however, the Agency has a data base for incineration of a similar waste (K037), which, according to 40 CFR 261.32, is listed as wastewater treatment sludge from the production of Disulfoton. Performance concentration levels for K037 wastewaters and nonwastewaters have already been promulgated (53 FR 31157, August 17, 1988). These standards were based on the performance of incineration of K037 nonwastewaters in a rotary kiln and the concentration of hazardous constituents found in the ash and scrubber water residuals.

The Agency's decision to transfer performance data standards for the nonwastewater forms of the organophosphorous wastes from the incineration of K037 wastes is based on the similarities in structure and elemental composition of all of the organophosphorous pesticides to each other and to Disulfoton, the principal hazardous constituent of concern in K037 wastes. As an example, the only difference in chemical structure between Phorate and Disulfoton is the additional methylene ($-CH_2-$) group in Disulfoton (see Figures 4-1 and 4-2).

Tables 4-1 through 4-6 of the Best Demonstrated Available Technology (BDAT) Background Document for K037 (USEPA 1988a) present the six data sets of total waste concentration analyses for K037 waste samples and the design and operating data for the incineration treatment system. As shown by the operating data taken during sample collection, all six data

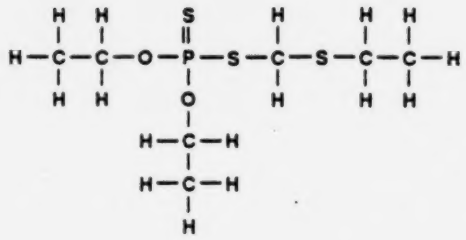


FIGURE 4-1 PHORATE CHEMICAL STRUCTURE

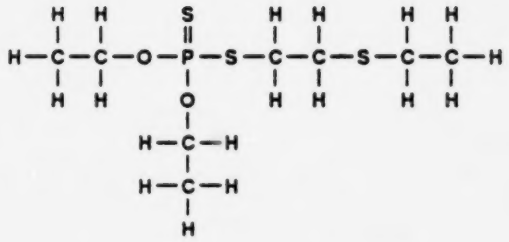


FIGURE 4-2 DISULFOTON CHEMICAL STRUCTURE

sets reflect treatment by a well-operated system. Furthermore, all the data sets show that the organic BDAT list constituents detected in the untreated wastes are treated to nondetectable levels in the treatment residuals.

The proposed treatment standards for the wastewater forms of these organophosphorous pesticides were based on the concentrations of Disulfoton as measured in grab samples of scrubber water from the incineration of K037 nonwastewaters. EPA has decided to change these standards in the final rule based on additional performance data for a biological wastewater treatment system submitted during the comment period. These data were from the treatment of industrial wastewaters containing low concentrations of Parathion. Table 4-1 presents this data set. Although these data (based on analysis of grab samples for influent wastes and composite samples for effluent) were not generated specifically for this rulemaking and do not result from the direct treatment of a RCRA waste identified as P089 (Parathion), the Agency believes that these wastewaters have concentrations of Parathion that are expected to be similar to the constituent concentrations in those wastewaters identified specifically as K036, K038, K040, P039, P071, P089, P094, P097 or U235. Available data for K038 wasatewaters show levels of Phorate in the same range as Parathion levels in wastewaters included in the biological treatment data received. The Agency has also determined that these data are valid and represent the level of performance that appears to be achievable for this type of biological wastewater treatment system.

EPA believes these data to be a preferable measure of treatment performance because where the Agency has performance data (that conform with BDAT methodology) on wastewater treatment processes and data on incineration (constituent concentrations in scrubber water), the Agency prefers to establish treatment standards based on the wastewater treatment processes. This does not preclude the Agency from establishing treatment standards for other wastes based on constituent concentrations in incinerator scrubber waters.

Table 4-1 Biological Treatment for Parathion

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
1	18	<0.01	47	26	<0.01
2	62	<0.01	48	15	<0.01
3	20	<0.01	49	16	<0.01
4	36	<0.01	50	29	<0.01
5	35	<0.01	51	36	<0.01
6	10	<0.01	52	41	<0.01
7	20	<0.01	53	18	<0.01
8	14	<0.01	54	5	<0.01
9	22	<0.01	55	6	<0.01
10	20	<0.01	56	59	<0.01
11	25	<0.01	57	31	<0.01
12	22	<0.01	58	22	<0.01
13	12	<0.01	59	24	<0.01
14	18	<0.01	60	28	<0.01
15	17	<0.01	61	30	<0.01
16	23	<0.01	62	15	<0.01
17	34	<0.01	63	15	<0.01
18	20	<0.01	64	30	<0.01
19	42	<0.01	65	25	<0.01
20	26	<0.01	66	12	<0.01
21	22	<0.01	67	17	<0.01
22	70	<0.01	68	23	<0.01
23	33	<0.01	69	15	<0.01
24	96	<0.01	70	18	<0.01
25	23	<0.01	71	21	<0.01
26	21	<0.01	72	26	<0.01
27	30	<0.01	73	17	<0.01
28	28	<0.01	74	12	<0.01
29	17	<0.01	75	20	<0.01
30	26	<0.01	76	9	<0.01
31	23	<0.01	77	18	<0.01
32	12	<0.01	78	15	<0.01
33	20	<0.01	79	11	<0.01
34	34	<0.01	80	17	<0.01
35	25	<0.01	81	18	<0.01
36	19	<0.01	82	9	<0.01
37	15	<0.01	83	20	<0.01
38	20	<0.01	84	18	<0.01
39	17	<0.01	85	17	<0.01
40	14	<0.01	86	21	<0.01
41	18	<0.01	87	8	<0.01
42	13	<0.01	88	21	<0.01
43	14	<0.01	89	15	<0.01
44	22	<0.01	90	18	<0.01
45	23	<0.01	91	9	<0.01
46	15	<0.01	92	11	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
93	11	<0.01	139	5	<0.01
94	16	<0.01	140	17	<0.01
95	14	<0.01	141	8	<0.01
96	16	<0.01	142	5	<0.01
97	22	<0.01	143	5	<0.01
98	10	<0.01	144	13	<0.01
99	22	<0.01	145	11	<0.01
100	15	<0.01	146	53	<0.01
101	14	<0.01	147	14	<0.01
102	12	<0.01	148	13	<0.01
103	21	<0.01	149	7	<0.01
104	14	<0.01	150	5	<0.01
105	14	<0.01	151	5	<0.01
106	9	<0.01	152	4	<0.01
107	16	<0.01	153	6	<0.01
108	9	<0.01	154	2	<0.01
109	14	<0.01	155	3	<0.01
110	20	<0.01	156	4	<0.01
111	24	<0.01	157	3	<0.01
112	5	<0.01	158	5	<0.01
113	4	<0.01	159	7	<0.01
114	7	<0.01	160	3	<0.01
115	8	<0.01	161	5	<0.01
116	10	<0.01	162	2	<0.01
117	13	<0.01	163	2	<0.01
118	6	<0.01	164	6	<0.01
119	13	<0.01	165	16	<0.01
120	9	<0.01	166	19	<0.01
121	6	<0.01	167	38	<0.01
122	5	<0.01	168	29	<0.01
123	7	<0.01	169	16	<0.01
124	7	<0.01	170	10	<0.01
125	4	<0.01	171	13	<0.01
126	5	<0.01	172	4	<0.01
127	5	<0.01	173	3	<0.01
128	9	<0.01	174	57	<0.01
129	7	<0.01	175	10	<0.01
130	6	<0.01	176	11	<0.01
131	9	<0.01	177	15	<0.01
132	7	<0.01	178	15	<0.01
133	11	<0.01	179	7	<0.01
134	3	<0.01	180	10	<0.01
135	3	<0.01	181	5	<0.01
136	1	<0.01	182	6	<0.01
137	6	<0.01	183	7	<0.01
138	21	<0.01	184	8	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
185	7	<0.01	231	6	0.01
186	5	<0.01	232	6	<0.01
187	5	<0.01	233	2	<0.01
188	10	<0.01	234	3	<0.01
189	7	<0.01	235	4	<0.01
190	9	<0.01	236	6	<0.01
191	4	<0.01	237	6	<0.01
192	13	<0.01	238	2	<0.01
193	7	<0.01	239	7	<0.01
194	9	<0.01	240	8	<0.01
195	8	<0.01	241	3	<0.01
196	7	<0.01	242	4	<0.01
197	6	<0.01	243	2	<0.01
198	9	<0.01	244	2	<0.01
199	5	<0.01	245	4	<0.01
200	8	<0.01	246	14	<0.01
201	5	<0.01	247	6	<0.01
202	9	<0.01	248	2	<0.01
203	4	<0.01	249	6	<0.01
204	5	<0.01	250	5	<0.01
205	5	<0.01	251	7	<0.01
206	6	<0.01	252	22	<0.01
207	2	<0.01	253	4	<0.01
208	5	<0.01	254	2	<0.01
209	7	<0.01	255	9	<0.01
210	4	<0.01	256	2	<0.01
211	7	<0.01	257	2	<0.01
212	3	<0.01	258	2	<0.01
213	2	<0.01	259	6	<0.01
214	6	<0.01	260	3	<0.01
215	3	<0.01	261	7	<0.01
216	3	<0.01	262	12	<0.01
217	2	<0.01	263	40	<0.01
218	2	<0.01	264	146	<0.01
219	3	<0.01	265	59	<0.01
220	3	<0.01	266	13	<0.01
221	2	<0.01	267	13	<0.01
222	2	<0.01	268	25	<0.01
223	2	<0.01	269	14	<0.01
224	4	<0.01	270	15	<0.01
225	4	<0.01	271	85	<0.01
226	7	<0.01	272	122	<0.01
227	2	<0.01	273	32	<0.01
228	5	<0.01	274	26	<0.01
229	8	<0.01	275	21	<0.01
230	2	<0.01	276	13	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
277	15	<0.01	323	7	<0.01
278	17	<0.01	324	6	<0.01
279	13	<0.01	325	14	<0.01
280	23	<0.01	326	13	<0.01
281	16	<0.01	327	11	<0.01
282	15	<0.01	328	12	<0.01
283	27	<0.01	329	11	<0.01
284	32	<0.01	330	7	<0.01
285	24	<0.01	331	7	<0.01
286	21	<0.01	332	11	<0.01
287	22	<0.01	333	8	<0.01
288	25	<0.01	334	8	<0.01
289	18	<0.01	335	6	<0.01
290	6	<0.01	336	6	<0.01
291	13	<0.01	337	12	<0.01
292	7	<0.01	338	8	<0.01
293	21	<0.01	339	11	<0.01
294	3	<0.01	340	6	<0.01
295	11	<0.01	341	15	<0.01
296	28	<0.01	342	9	<0.01
297	16	<0.01	343	5	<0.01
298	7	<0.01	344	8	<0.01
299	40	<0.01	345	16	<0.01
300	20	<0.01	346	17	<0.01
301	11	<0.01	347	11	<0.01
302	18	<0.01	348	13	<0.01
303	12	<0.01	349	7	<0.01
304	8	<0.01	350	15	<0.01
305	23	<0.01	351	9	<0.01
306	11	<0.01	352	9	<0.01
307	18	<0.01	353	9	<0.01
308	26	<0.01	354	11	<0.01
309	10	<0.01	355	14	<0.01
310	11	<0.01	356	5	<0.01
311	8	<0.01	357	4	<0.01
312	5	<0.01	358	8	<0.01
313	11	<0.01	359	8	<0.01
314	12	<0.01	360	20	<0.01
315	20	<0.01	361	5	<0.01
316	6	<0.01	362	6	0.01
317	9	<0.01	363	14	<0.01
318	9	<0.01	364	9	<0.01
319	11	<0.01	365	13	<0.01
320	9	<0.01	366	7	<0.01
321	8	<0.01	367	10	<0.01
322	3	<0.01	368	9	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
369	9	<0.01	415	7	<0.01
370	9	<0.01	416	5	<0.01
371	7	<0.01	417	14	<0.01
372	6	<0.01	418	6	<0.01
373	5	<0.01	419	6	<0.01
374	9	<0.01	420	4	<0.01
375	7	<0.01	421	3	<0.01
376	11	<0.01	422	6	<0.01
377	17	<0.01	423	6	<0.01
378	13	<0.01	424	12	<0.01
379	22	<0.01	425	3	<0.01
380	7	<0.01	426	2	<0.01
381	14	<0.01	427	2	<0.01
382	7	<0.01	428	2	<0.01
383	6	<0.01	429	2	<0.01
384	6	<0.01	430	2	<0.01
385	5	<0.01	431	3	<0.01
386	6	<0.01	432	3	<0.01
387	6	<0.01	433	3	<0.01
388	13	<0.01	434	6	<0.01
389	10	<0.01	435	3	<0.01
390	5	<0.01	436	5	<0.01
391	17	<0.01	437	6	<0.01
392	11	<0.01	438	8	<0.01
393	20	<0.01	439	9	<0.01
394	20	<0.01	440	9	<0.01
395	9	<0.01	441	4	<0.01
396	9	<0.01	442	7	<0.01
397	9	<0.01	443	10	<0.01
398	11	<0.01	444	6	<0.01
399	9	<0.01	445	5	<0.01
400	7	<0.01	446	5	<0.01
401	5	<0.01	447	5	<0.01
402	9	<0.01	448	3	<0.01
403	5	<0.01	449	3	<0.01
404	8	<0.01	450	8	<0.01
405	9	<0.01	451	5	<0.01
406	4	<0.01	452	8	<0.01
407	9	<0.01	453	4	<0.01
408	6	0.01	454	7	<0.01
409	8	<0.01	455	2	<0.01
410	5	<0.01	456	5	<0.01
411	7	<0.01	457	3	<0.01
412	10	<0.01	458	6	<0.01
413	3	<0.01	459	4	<0.01
414	6	<0.01	460	4	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
461	5	<0.01	507	3	<0.01
462	9	<0.01	508	4	<0.01
463	5	<0.01	509	4	<0.01
464	5	<0.01	510	5	<0.01
465	7	<0.01	511	5	<0.01
466	8	<0.01	512	4	<0.01
467	3	<0.01	513	4	<0.01
468	3	<0.01	514	4	<0.01
469	2	<0.01	515	4	<0.01
470	4	<0.01	516	4	<0.01
471	3	<0.01	517	5	<0.01
472	4	<0.01	518	15	<0.01
473	5	<0.01	519	10	<0.01
474	4	<0.01	520	6	<0.01
475	4	<0.01	521	3	<0.01
476	2	<0.01	522	10	<0.01
474	2	<0.01	523	17	<0.01
475	2	<0.01	524	21	<0.01
479	1	<0.01	525	37	<0.01
480	4	<0.01	526	72	<0.01
481	2	<0.01	527	31	<0.01
482	2	<0.01	528	20	<0.01
483	9	<0.01	529	30	<0.01
484	4	<0.01	530	22	<0.01
485	6	<0.01	531	35	<0.01
486	7	<0.01	532	16	<0.01
487	6	<0.01	533	12	<0.01
488	9	<0.01	534	18	<0.01
489	9	<0.01	535	32	<0.01
490	5	<0.01	536	33	<0.01
491	3	<0.01	537	37	<0.01
492	5	<0.01	538	13	<0.01
493	6	<0.01	539	5	<0.01
494	3	<0.01	540	6	<0.01
495	3	<0.01	541	5	<0.01
496	4	<0.01	542	13	<0.01
497	1	<0.01	543	7	<0.01
498	1	<0.01	544	4	<0.01
499	6	<0.01	545	12	<0.01
500	3	<0.01	546	8	<0.01
501	2	<0.01	547	21	<0.01
502	6	<0.01	548	17	<0.01
503	6	<0.01	549	13	<0.01
504	5	<0.01	550	8	<0.01
505	8	<0.01	551	13	<0.01
506	4	<0.01	552	6	<0.01

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
553	9	<0.01	599	11	<0.01
554	10	<0.01	600	5	<0.01
555	17	<0.01	601	4	<0.01
556	12	<0.01	602	7	<0.01
557	12	<0.01	603	5	<0.01
558	11	<0.01	604	12	<0.01
559	3	<0.01	605	9	0.01
560	7	<0.01	606	2.4	0.002
561	7	<0.01	607	2.6	0.001
562	7	<0.01	608	0.8	0.002
563	13	<0.01	609	1.5	0.002
564	5	<0.01	610	1.0	0.004
565	10	<0.01	611	1.9	0.002
566	15	<0.01	612	1.3	0.001
567	11	<0.01	613	4.1	0.003
568	14	<0.01	614	13.6	0.003
569	7	<0.01	615	5.0	0.005
570	14	<0.01	616	6.5	0.014
571	10	<0.01	617	7.7	0.002
572	12	<0.01	618	4.9	0.003
573	21	<0.01	619	5.4	0.004
574	5	<0.01	620	4.1	0.002
575	5	<0.01	621	4.9	0.003
576	10	<0.01	622	10.8	0.002
577	9	<0.01	623	9.0	0.004
578	14	<0.01	624	7.7	0.004
579	12	<0.01	625	5.6	0.004
580	9	<0.01	626	7.5	0.015
581	26	<0.01	627	8.5	0.013
582	37	<0.01	628	10.4	0.008
583	11	<0.01	629	15.2	0.004
584	11	<0.01	630	16.2	0.003
585	8	<0.01	631	9.7	0.002
586	6	<0.01	632	3.9	0.004
587	9	<0.01	633	4.7	0.003
588	20	<0.01	634	6.1	0.018
589	7	<0.01	635	11.0	0.002
590	17	<0.01	636	7.7	0.002
591	9	<0.01	637	8.6	0.002
592	10	<0.01	638	10.7	0.006
593	5	<0.01	639	3.0	0.016
594	7	<0.01	640	6.8	0.009
595	6	<0.01	641	6.3	0.008
596	2	<0.01	642	17.1	0.010
597	19	<0.01	643	9.1	0.006
598	21	<0.01	644	5.3	0.008

Table 4-1 (continued)

Sample number	Untreated waste (ppm)	Treated waste (ppm)	Sample number	Untreated waste (ppm)	Treated waste (ppm)
645	4.3	0.002	669	15.3	0.006
646	8.5	0.006	670	20.2	0.003
647	8.8	0.008	671	11.5	0.005
648	5.6	0.005	672	37.4	0.010
649	5.8	0.004	673	10.0	0.007
650	6.9	0.001	674	10.5	0.002
651	14.8	0.007	675	15.3	0.005
652	9.2	0.005	676	6.4	0.002
653	8.4	0.003	677	4.5	0.001
654	4.8	0.002	678	15.4	0.002
655	6.8	0.004	679	13.6	0.006
656	19.0	0.001	680	10.1	0.003
657	5.9	0.002	681	9.3	0.002
658	5.7	0.005	682	2.1	0.002
659	7.0	0.003	683	1.6	0.003
660	2.7	0.003	684	1.4	0.003
661	9.9	0.002	685	1.9	0.004
662	6.6	0.004	686	2.2	0.004
663	10.0	0.004	687	4.8	0.004
664	12.8	0.003	688	7.5	0.003
665	12.7	0.003	689	3.3	<0.001
666	15.3	0.004	690	2.3	0.001
667	9.9	0.006	691	2.6	<0.001
668	5.6	0.002	692	1.5	0.001

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY

This section presents the Agency's rationale for the determination of best demonstrated available technology (BDAT) for the organophosphorous nonwastewaters and wastewaters. BDAT must be specifically defined for all streams associated with the management of the listed waste or wastes; this pertains to the original waste as well as to any residual waste streams created by the treatment process.

To determine BDAT, the Agency examines all available performance data on technologies that are identified as demonstrated to determine (using statistical techniques) whether one or more of the technologies performs significantly better than the others. In addition, all performance data used for determination of best technology are first adjusted for accuracy, as discussed in EPA's publication Methodology for Developing BDAT Treatment Standards (USEPA 1988c). (An accuracy adjustment accounts for the ability of an analytical technique to recover a particular constituent from the waste in a particular test. The recovery of a constituent is usually determined by spiking a raw waste sample with a known amount of the target constituent and then comparing the amount recovered with results from unspiked samples of the waste.)

The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available the technology must (1) be commercially available to any generator and (2) provide "substantial" treatment of the waste, as determined through evaluation of accuracy-adjusted data. In

determining whether treatment is substantial, EPA may consider data on the performance of a waste similar to the waste in question provided that the similar waste is at least as difficult to treat. If the best technology is found to be not available, then the next best technology is evaluated, and so on.

The Agency is promulgating BDAT treatment standards based on hazardous constituent concentrations for the wastewater and nonwastewater forms of K038, K040, P039, P071, P089, P094, P097, and U235 and the wastewater forms of K036. As previously discussed, the Agency currently is not able to adequately analyze the constituents of the K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087 treatment residues; thus, it is promulgating standards that require a specific treatment technology for the wastewater and nonwastewater forms of this waste, rather than constituent concentration standards.

5.1 Nonwastewaters

Consistent with EPA's methodology for determining BDAT, the Agency evaluated the incineration performance data for the similar waste (K037) to determine whether this technology would provide statistically significant treatment for BDAT list organic constituents in the wastes in this treatability group. Based on the evaluation of the design and operating parameters of the treatment system, the analytical testing, and the quality of the data, EPA determined that incineration does provide statistically significant treatment. This determination is based on the fact that the BDAT list organic constituents were reduced to nondetectable

levels in the treatment residuals. Incineration is also a widely available commercial technology. Consequently, the Agency concluded that incineration alone is BDAT for the nonwastewater forms of these wastes.

Performance data for a similar waste (K037) indicated that organic residuals in the ash and the scrubber water were below detection limits. The Phorate detection limit was 0.0165 mg/kg for the treated waste and 0.5 mg/l for the scrubber water (USEPA 1988a). The Agency concluded that there is no need for additional treatment of nonwastewater or wastewater residuals resulting from incineration of K037 and that incineration alone is BDAT for all nonwastewaters of this waste. Since the wastes in this treatability group are similar to K037 (Disulfoton), the Agency likewise concluded that incineration is demonstrated, and thus it was selected for determination of BDAT treatment standards for all nonwastewater forms of these wastes. As with K037 treatment residuals, the Agency concluded that there is no need for additional treatment of nonwastewater and wastewater incineration residuals of these treated wastes.

5.2 Wastewaters

For those wastewaters for which the principal hazardous constituent can be measured, EPA proposed performance standards based on concentrations of Disulfoton as measured in grab samples of scrubber water from the incineration of K037 nonwastewaters. EPA has decided to change these standards in the final rule based on additional performance data (concentrations of Parathion as measured in composite samples) for a biological wastewater treatment system submitted by Monsanto during the comment period. These data (see Table 4-1) indicate that wastewater

streams containing Parathion managed by biological treatment were treated to levels at or nearly at the detection limit levels found for incinerator scrubber water. The Agency has also determined that these data are valid and represent the level of performance that appears to be achievable for this type of biological wastewater treatment system.

EPA believes that these data for biological treatment of Parathion can be validly transferred to the wastewater forms of the other organophosphorous pesticide waste codes. This is due to the structural similarity between Parathion and the other organophosphorous wastes. Thus, the Agency is promulgating revised concentration-based standards for the wastewater forms of K036, K038, K040, P039, P071, P087, P094, P097, and U235 based on analysis of composite samples from wastewater treatment.

The Agency has determined that currently there are no analytical methods that allow the measurement of the principal hazardous constituent (organophosphorous pesticide) contained in wastes and treatment residuals for wastes identified as K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. Thus, the Agency is unable to promulgate concentration-based treatment standards for these wastes and is promulgating methods of treatment. Although EPA prefers a concentration-based standard (both because of the greater flexibility in choice of technology used to achieve the standard and the greater control afforded to ensure efficient design and operation of the chosen technology), in the absence of analytical methods (that would measure and assure compliance), the Agency believes that establishing a method of

treatment is the only logical alternative for BDAT. In general, the majority of commenters on this issue supported this approach. Further, EPA believes that this is consistent with the promulgated BDAT methodology and with RCRA section 3004(m), which authorizes the Agency to establish either levels or methods of treatment. Therefore, today's rule promulgates methods of treatment for these wastes.

For the wastewater forms of these organophosphorous wastes, the Agency proposed carbon adsorption as the BDAT treatment method in 54 FR 1086 (January 11, 1989). EPA believes that the primary constituents of these wastes can easily be adsorbed on carbon because of the chemical and physical properties of the compounds (such as their molecular weight, elemental composition, and structural form). Spent carbon and any other nonwastewater residuals generated upstream from a carbon adsorption unit must meet the nonwastewater standards applicable to these wastes prior to land disposal.

Several commenters suggested that there are cases in which it may be preferable to incinerate the wastewater rather than to have the waste adsorbed by carbon. Two examples of this situation occur when: (1) the waste appears as a result of the "mixture-rule" with other waste codes for which the BDAT treatment method requires incineration, and (2) the waste is generated so that it contains a relatively high level of TOC but just under the 1 percent TOC cutoff and maintains its classification (for purposes of BDAT) as a wastewater. In either case, the Agency agrees with the commenter that incineration would then be the preferred or required (as in the case of the first example) method of treatment. In

fact, the Agency did consider incineration as an alternative destructive technology to carbon adsorption. However, it seemed impractical to require all wastewater streams to be incinerated. (Some data indicated that the majority of hazardous wastewaters contain significantly less than 1 percent TOC.)

Thus, the Agency is promulgating "Incineration or Carbon Adsorption as a Method of Treatment" as BDAT for the wastewater forms of wastes identified as K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087.

6. SELECTION OF REGULATED CONSTITUENTS

This section presents the rationale for the selection of regulated constituents for the treatment of K036, K038, K039, and K040 wastes.

Constituents selected for regulation must satisfy the following criteria:

1. They must be on the BDAT list of regulated constituents. (Presence on the BDAT list implies the existence of approved techniques for analyzing the constituent in treated waste matrices.)

2. They must be present in, or be suspected of being present in, the untreated waste. For example, in some cases, analytical difficulties (such as masking) may prevent a constituent from being identified in the untreated waste, but its identification in a treatment residual may lead the Agency to conclude that it is present in the untreated waste.

3. Where performance data are transferred, the selected constituents must be easier to treat than the waste constituent(s) from which performance data are transferred. Factors for assessing ease of treatment will vary according to the technology of concern. For instance, for incineration the factors include bond dissociation energy, thermal conductivity, and boiling point.

From the group of constituents that are eligible to be regulated, EPA may select a subset of constituents as representative of the broader group. For example, out of a group of constituents that react similarly to treatment, the Agency might name only those that are the most difficult to treat as regulated constituents for the purpose of setting a standard.

6.1 Identification of BDAT List Constituents

As discussed in Sections 2 and 4, the Agency has characterization data for K038, K039, and K040, as well as performance data from treatment of a similar waste (K037) and from treatment of Parathion. These data,

along with information on the waste-generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in K038, K039, and K040 wastes. Constituents that were not expected to be in the untreated waste were not considered for regulation. The other U and P wastes in this treatability group do not require a constituent selection since there is only one constituent that characterizes each one of them.

6.2 Constituent Selection

Since there are no treatment performance data from incineration of K038, K039, and K040, the Agency has transferred performance data from the treatment of K037 at plant A (USEPA 1988a) to the above-listed wastes. This transfer of treatment data is supported both by the determination that all of these wastes are generated by the organophosphorous industry and by the Agency's belief that constituents present in K038, K039 and K040 are similar to those in K037, and thus are amenable to the same treatment technology.

The determination of adequate control for the constituents was based on an evaluation of the characteristics of the constituents (i.e., the boiling point and the bond dissociation energy) that would affect the performance of incineration. In general, a constituent with a low boiling point and low dissociation energy would be easier to treat by incineration than would constituents with higher boiling points and higher dissociation energies.

The constituent having the same or the closest higher boiling point and bond dissociation energy, for which the Agency had treatment performance data from K037 at plant A, was selected for transfer of data.

Phorate is the only BDAT list constituent expected to be present in K038 and K040 wastes. It also has characteristics similar to Disulfoton, the constituent treated and regulated in the similar waste (K037). Table 6-1 presents the constituent characteristics that affect the performance of incineration for the K037 regulated constituent (Disulfoton), from which the standards are being transferred, and for the K038 and K040 constituent to be regulated (Phorate). As can be seen in this table, the boiling point and the bond dissociation energy values of Phorate are lower than the values for Disulfoton. This condition indicates that Phorate should be easier to incinerate than Disulfoton. The EPA-approved analytical methods for measurement of Phorate in the wastes and treated residuals for K038 and K040 are listed in the SW-846 publication as methods 8140 and 8141 (USEPA 1986a).

Based on the discussion of waste characteristics affecting treatment performance of incineration in the Treatment Technologies Background Document, the Agency expects that Phorate can be treated to concentration levels as low as or lower than Disulfoton.

Because the Agency has determined that currently, there are no analytical methods that allow the measurement of the principal hazardous constituents contained in K039 wastes and treatment residuals, numerical standards cannot be established. However, since the constituents in

Table 6-1 Waste Characteristics Affecting Performance of Incineration

Constituent	Waste code	Boiling point	Bond dissociation energy (Kcal/mol)
Disulfoton	K037	132° - 133°C(1.5mm Hg)[a]	2860
Phorate	K038, K040	125° - 127°C(2.0mm Hg)[a]	2755

[a] Merck and Co., 1983.

Table 6-2 Regulated Constituents for K038 and K040

Waste code	Regulated constituent
K038	Phorate
K040	Phorate

these wastes are structurally similar to Phorate and are generated during its production, the Agency has determined that incineration is BDAT for this waste, as noted in Section 5. Because the K039 constituents cannot be analyzed at the treated levels, however, the Agency is requiring the use of the incineration technology as BDAT and not setting a performance concentration level standard for any particular constituents.

Table 6-2 shows the BDAT list constituents that were selected by the Agency to regulate K038 and K040 wastes.

7. DEVELOPMENT OF BDAT TREATMENT STANDARDS

The Agency bases treatment standards for regulated constituents on the performance of well-designed and well-operated BDAT treatment systems. These standards must account for analytical limitations in available performance data and must be adjusted for variabilities related to treatment, sampling, and analytical techniques and procedures.

BDAT standards are determined for each constituent by multiplying the arithmetic mean of accuracy-adjusted constituent concentrations detected in treated waste by a "variability factor" specific to each constituent. Accuracy adjustment of performance data was discussed in Section 5 in relation to defining "substantial treatment." Variability factors correct for normal variations in the performance of a particular technology over time. They are designed to reflect the 99th percentile level of performance that the technology achieves in commercial operation. (For more information on the principles of calculating variability factors, see EPA's publication, Methodology for Developing BDAT Treatment Standards. For details on the calculation of variability factors for the organophosphorous wastes, see Appendix A of the Best Demonstrated Available Technology (BDAT) Background Document for K037 (USEPA 1988a).)

Where EPA has identified BDAT for a particular waste but because of data limitations or some other compelling reason cannot define specific concentration treatment standards for that waste, the Agency can require the use of that treatment process as a technology standard. Similarly,

where EPA believes that the waste can be totally recycled or reused as a raw material, the Agency may specify a "no land disposal" standard, which effectively amounts to setting the performance standard at zero for all waste constituents.

In the case of K036, K038, K040, P039, P071, P089, P094, P097, and U235, the Agency is promulgating concentration-based treatment standards for the regulated constituent as shown in Tables 7-1 and 7-2. The nonwastewater treatment standard of 0.10 ppm is directly transferred from the performance achieved by rotary kiln incineration of K037 and the concentration of organophosphorous pesticide measured in the ash residual. Standards applicable to the wastewaters are based on the performance achieved by biological treatment and the concentration of pesticide measured in the resultant effluent wastewaters. Where the treatment standards are expressed as concentration-based treatment standards, the use of other technologies to achieve these standards is not precluded from use by this rule.

The proposed treatment standards for the wastewater forms of these organophosphorous pesticides were based on the concentrations of Disulfoton as measured in grab samples of scrubber water from the incineration of K037 nonwastewaters. EPA has decided to change these standards in the final rule based on additional performance data for a biological wastewater treatment system submitted during the comment period. The Agency believes that these wastewaters have concentrations

Table 7-1 BDAT Nonwastewater Treatment Standards for K038, K040, P039, P071, P089, P094, P097, and U235

Waste code	Regulated constituents	Constituent from which treat. data were transferred	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
K038	Phorate	Disulfoton	0.040	2.8	0.10
K040	Phorate	Disulfoton	0.040	2.8	0.10
P039	Disulfoton	Disulfoton	0.040	2.8	0.10
P071	Methyl parathion	Disulfoton	0.040	2.8	0.10
P089	Parathion	Disulfoton	0.040	2.8	0.10
P094	Phorate	Disulfoton	0.040	2.8	0.10
P097	Famphur	Disulfoton	0.040	2.8	0.10
U235	tris-(2,3-Dibromopropyl phosphate)	Disulfoton	0.040	2.8	0.10

(For any single grab sample)

Table 7-2 BDAT Wastewater Treatment Standards for K036, K038, K040, P039, P071, P089, P094, P097, and U235

Waste code	Regulated constituents	Constituent from which treat. data were transferred	Arithmetic average of corrected treat. values (ppm)	Variability factor (VF)	Treatment standard (Ave. x VF) (ppm)
K036	Disulfoton	Parathion	0.0093	2.64	0.025
K038	Phorate	Parathion	0.0093	2.64	0.025
K040	Phorate	Parathion	0.0093	2.64	0.025
P039	Disulfoton	Parathion	0.0093	2.64	0.025
P071	Methyl parathion	Parathion	0.0093	2.64	0.025
P089	Parathion	Parathion	0.0093	2.64	0.025
P094	Phorate	Parathion	0.0093	2.64	0.025
P097	Famphur	Parathion	0.0093	2.64	0.025
U235	tris-(2,3-Dibromopropyl phosphate)	Parathion	0.0093	2.64	0.025

(For any composite sample)

of Parathion that are expected to be similar to constituent concentrations in those wastewaters identified specifically as K036, K038, K040, P039, P071, P089, P094, P097, or U235. Therefore, revised concentration-based standards for the wastewater forms of K036, K038, K040, P039, P071, P089, P094, P097, and U235 based on analysis of composite samples from wastewater treatment are promulgated.

The Agency has determined that currently there are no analytical methods that allow the measurement of the principal hazardous constituent (organophosphorous pesticide) contained in wastes and treatment residuals for wastes identified as K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. Thus, the Agency is unable to promulgate concentration-based treatment standards for these wastes and is promulgating methods of treatment. Although EPA prefers a concentration-based standard (both because of the greater flexibility in choice of technology used to achieve the standard and the greater control afforded to ensure efficient design and operation of the chosen technology), in the absence of analytical methods (that would measure and assure compliance), the Agency believes that establishing a method of treatment is the only logical alternative for BDAT. Further, EPA believes that this is consistent with the promulgated BDAT methodology and with RCRA section 3004(m), which authorizes the Agency to establish either levels or methods of treatment.

As discussed previously, the Agency believes that incineration represents BDAT for the nonwastewater forms of these wastes. Besides the fact that EPA does not currently have an analytical method for this group of organophosphorous pesticides, EPA has not identified any organic constituents in these wastes that could be used as a surrogate or as an indicator compound in order to develop alternative concentration- based standards for these wastes. Therefore, the Agency is promulgating a BDAT treatment standard of "Incineration as a Method of Treatment" for the nonwastewater forms of K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087.

For the wastewater forms of these organophosphorous wastes, the Agency proposed carbon adsorption as the BDAT treatment method in 54 FR 1086 (January 11, 1989). The residual from this type of nondestructive treatment, i.e., the spent carbon, is still considered to be the same waste code as before treatment, and must be managed as such. It therefore must be incinerated prior to land disposal.

It should be noted that the use of other treatment technologies prior to carbon adsorption is not prohibited by this rule. Carbon adsorption is often used at the end of a treatment train, after the constituent concentrations are reduced by technologies such as chemical oxidation, hydrolysis or biodegradation. Any nonwastewater residues from these treatment technologies prior to and including carbon adsorption would have to be incinerated in order to meet the treatment standard. The wastewater effluent from carbon adsorption would be considered to meet the treatment standard.

As explained in Section 5.2 several commenters suggested that there are cases where it may be preferable to incinerate the wastewater rather than have the waste adsorbed by carbon. Thus, the Agency is promulgating "Incineration or Carbon Adsorption as a Method of Treatment" as BDAT for the wastewater forms of wastes identified as K039, P040, P041, P043, P044, P062, P085, P109, P111, U058, and U087. Spent carbon and any other nonwastewater residuals generated upstream from a carbon adsorption unit must meet the nonwastewater standards applicable to these wastes prior to land disposal. Carbon adsorption units must be operated so that breakthrough of organophosphorous compounds does not occur. Selection of a surrogate or indicator compound of this breakthrough should be made on a case-by-case basis.

8. REFERENCES

APHA, AWWA, and WPCF. 1985. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Standard methods for the examination of water and wastewater. 16th ed. Washington, D.C.: American Public Health Association.

Environ Corporation. (n.d.). Characterization of waste streams listed in 40 CFR Section 261 waste profiles, Vol. II. Prepared for Waste Identification Branch, Characterization and Assessment Division, U.S. Environmental Protection Agency. Washington, D.C.: U.S. Environmental Protection Agency.

Merck and Co. 1983. Merck index, 10th ed. Rahway, N.J.

USEPA. 1986a. U.S. Environmental Protection Agency, Office of Solid Waste. Test methods for evaluation of solid waste; physical/chemical methods, SW-846. 3rd ed. Washington, D.C.: U.S. Environmental Protection Agency.

USEPA. 1986b. U.S. Environmental Protection Agency, Office of Solid Waste. Computer printout: Data on organophosphorous wastes. National survey of hazardous waste treatment, storage, disposal, and recycling facilities. Retrieved October 1988. Washington, D.C.: U.S. Environmental Protection Agency.

USEPA. 1987. U.S. Environmental Protection Agency, Office of Solid Waste. Generic quality assurance project plan for Land Disposal Restrictions Program ("BDAT"). Washington, D.C.: U.S. Environmental Protection Agency.

USEPA. 1988a. U.S. Environmental Protection Agency, Office of Solid Waste. Best demonstrated available technology (BDAT) background document for K037. Washington, D.C.: U.S. Environmental Protection Agency.

USEPA. 1988b. U.S. Environmental Protection Agency, Office of Solid Waste. Land Disposal Restrictions for First Third Scheduled Wastes; Final Rule. 53 FR 31157, August 17, 1988.

USEPA. 1988c. U.S. Environmental Protection Agency, Office of Solid Waste. Methodology for developing BDAT treatment standards. Washington, D.C.: U.S. Environmental Protection Agency.

USEPA. 1988d. U.S. Environmental Protection Agency, Office of Solid Waste. Treatment technologies background document. Washington, D.C.: U.S. Environmental Protection Agency.